# A Multi-Scale Modeling and Data Assimilation System to Support SPURS Field Experiment and Study Upper Ocean Salinity Processes

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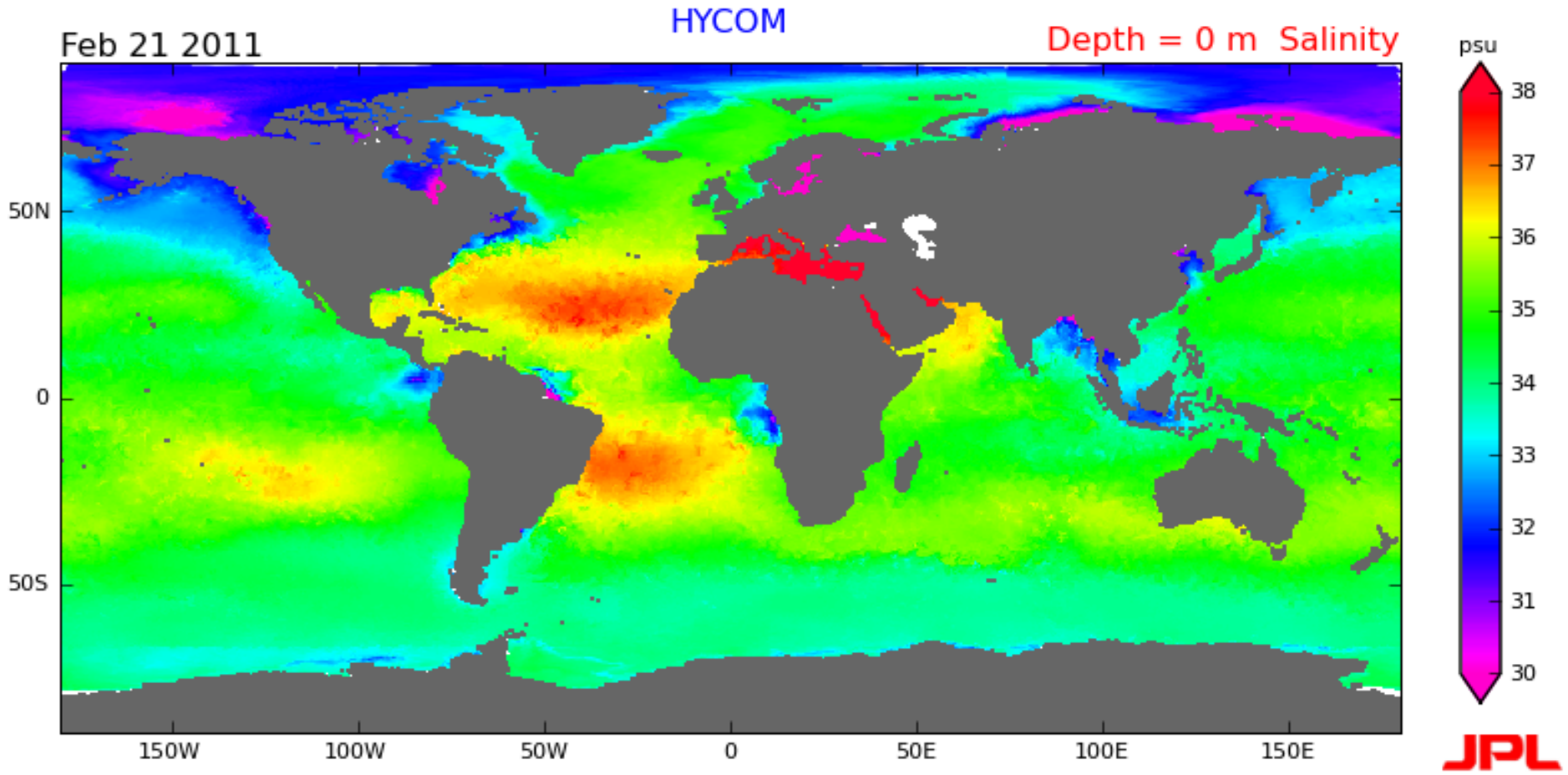
# Objectives

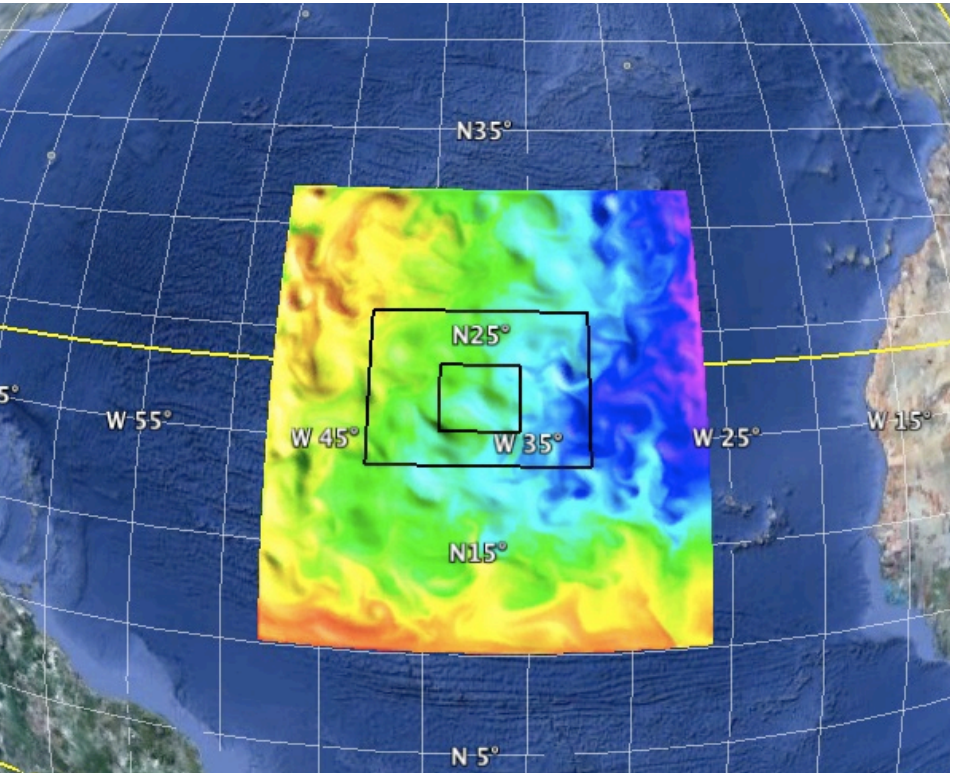
1. Conduct Observing System Simulation Experiments (OSSEs) before the SPURS field campaign
2. Provide real-time nowcasts and forecasts during the SPURS field campaign to support decision making
3. Produce a reanalysis assimilating all the SPURS and other observational data into the nested model to study the processes controlling the upper ocean salinity.

# Global 1/12° HYCOM (NAVO/FSU)

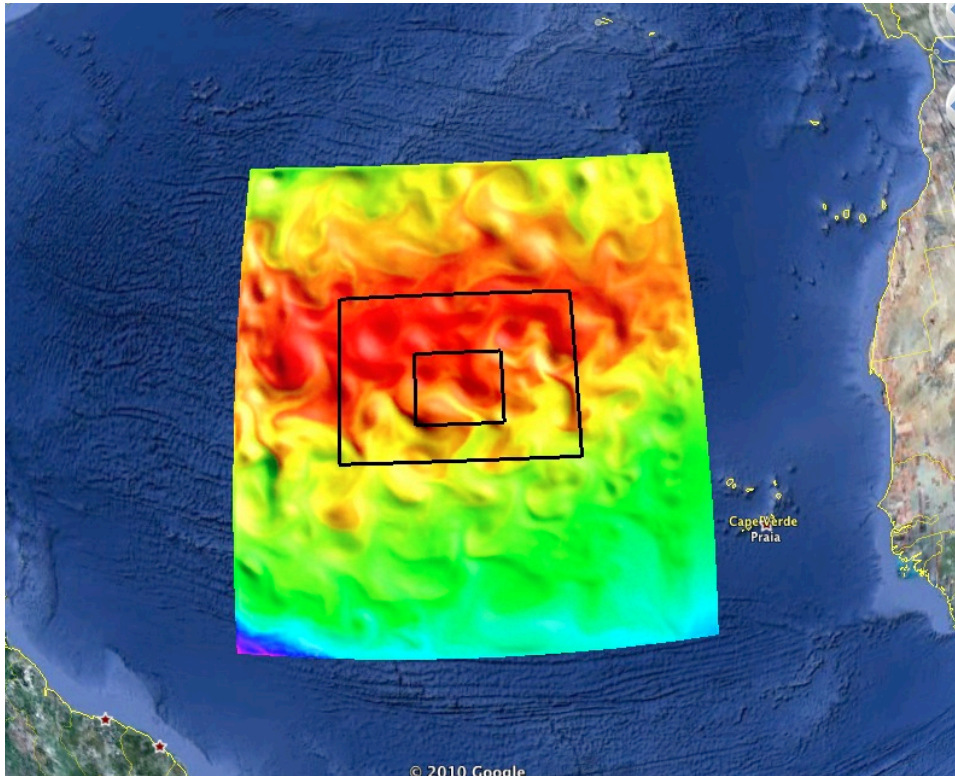


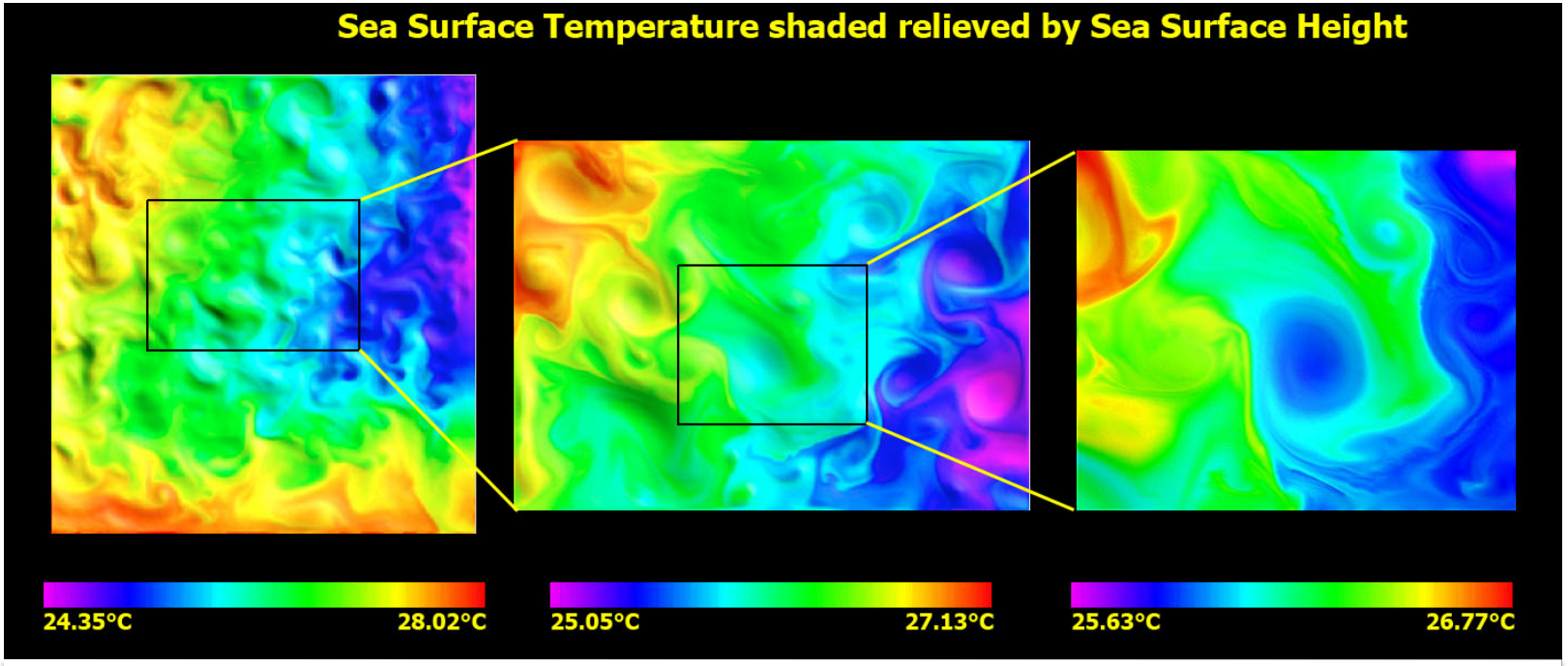
# SPURS Regional Ocean Modeling System (ROMS)

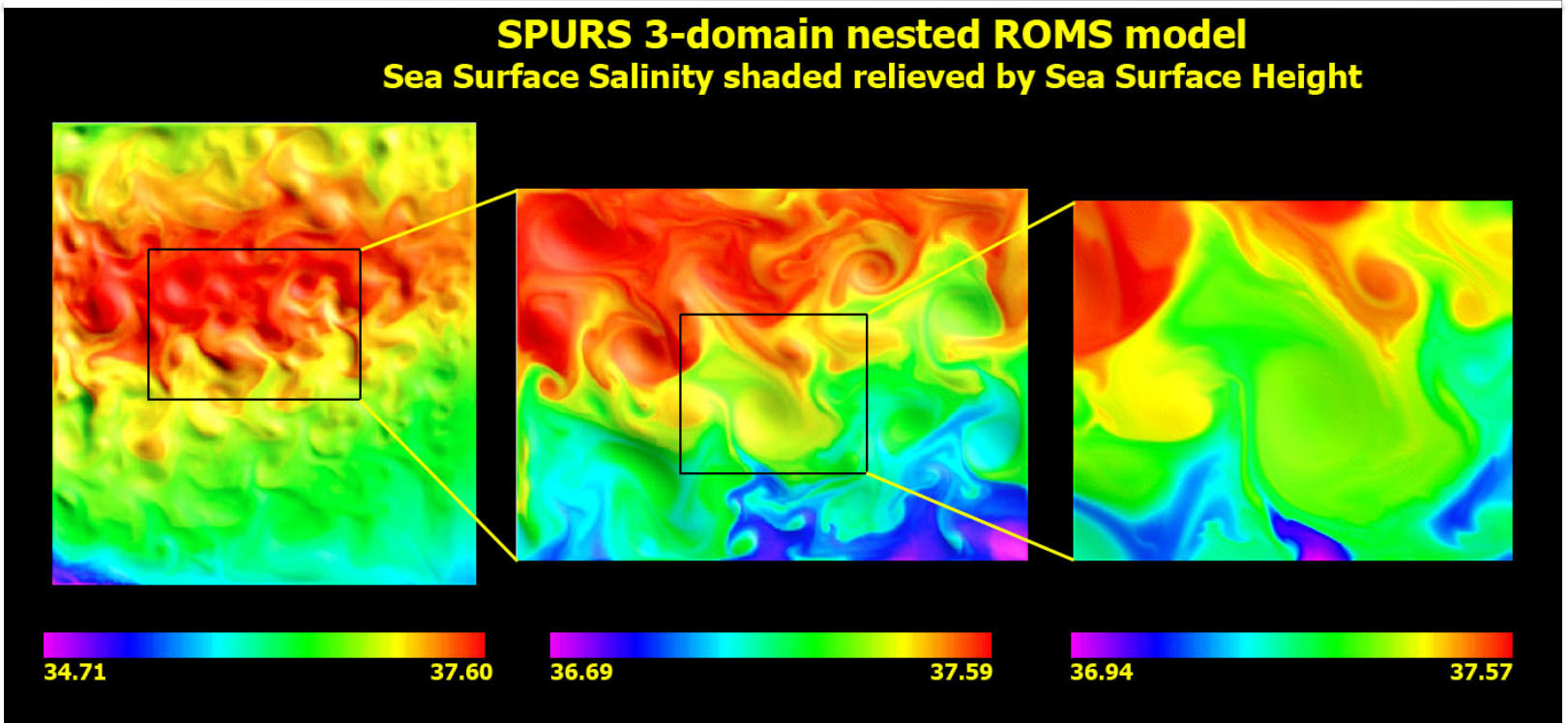
Sea Surface Temperature




Sea Surface Salinity




Sea Surface Temperature shaded relieved by Sea Surface Height
24.35°C
28.02°C
25.05°C
27.13°C
25.63°C
26.77°C


SPURS 3-domain nested ROMS model
Sea Surface Salinity shaded relieved by Sea Surface Height
34.71
37.60
36.69
37.59
36.94
37.57

# 3-D Variational Data Assimilation (3DVAR)

$$J = J_B + J_O = 0.5\,(x-x^f)^T B^{-1} (x-x^f) + 0.5\,(h\,x-y)^T O^{-1} (h\,x-y)$$

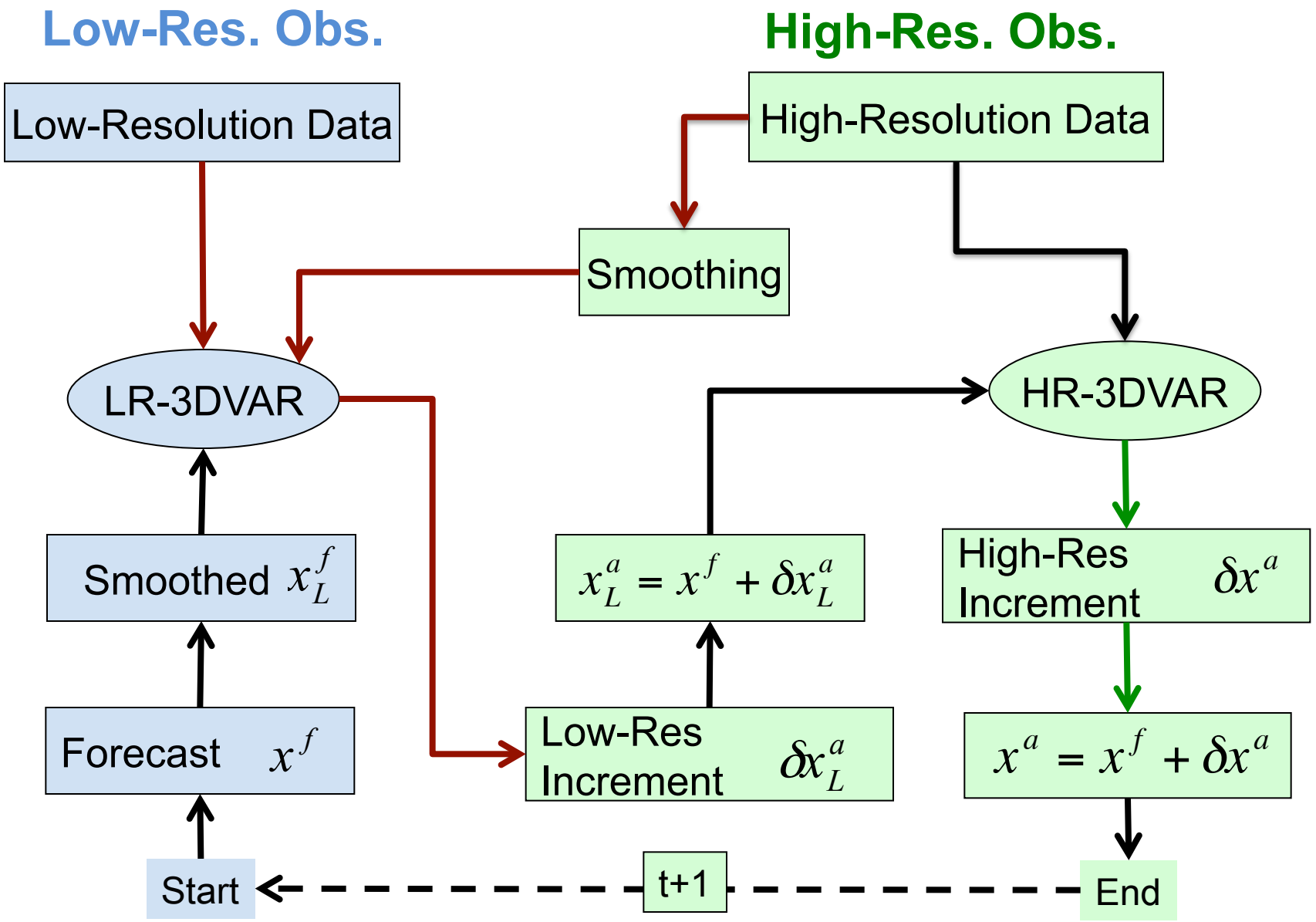
$$x = \begin{pmatrix} \varsigma \\ u \\ v \\ T \\ S \end{pmatrix} = \begin{pmatrix} x_\varsigma \\ x_{uv} \\ x_{TS} \end{pmatrix} = \begin{pmatrix} x^f_\varsigma + \Pi\,\delta x_{TS} + \delta x_{a\varsigma} \\ x^f_{uv} + \Gamma\,\delta x_{TS} + \Phi_a\,\delta x_{a\psi\chi} \\ x^f_{TS} + \delta x_{TS} \end{pmatrix}$$

$\delta x^G_{uv} = \Gamma\,\delta x_{TS}$ Geostrophic balance

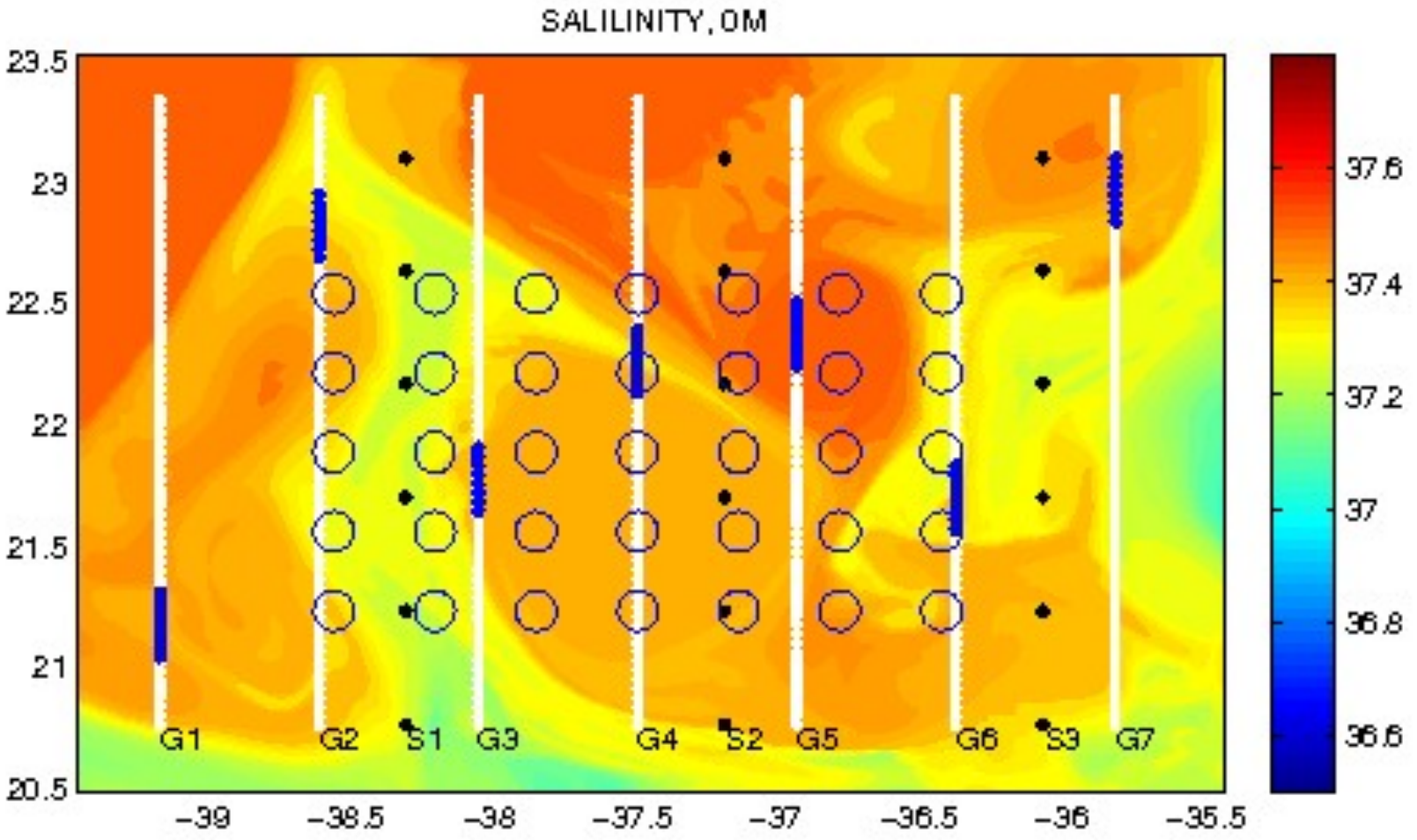
$\delta x^S_\varsigma = \Pi\,\delta x_{TS}$ Hydrostatic equation

Five Control Variables:
Temperature: $\delta T$
Salinity: $\delta S$
Non-steric SSH: $\delta X_{a\zeta}$
Ageostrophic streamfunction: $\delta X_{a\psi}$
Ageostrophic velocity potential: $\delta X_{a\chi}$

# Multi-Scale 3DVAR Data Assimilation

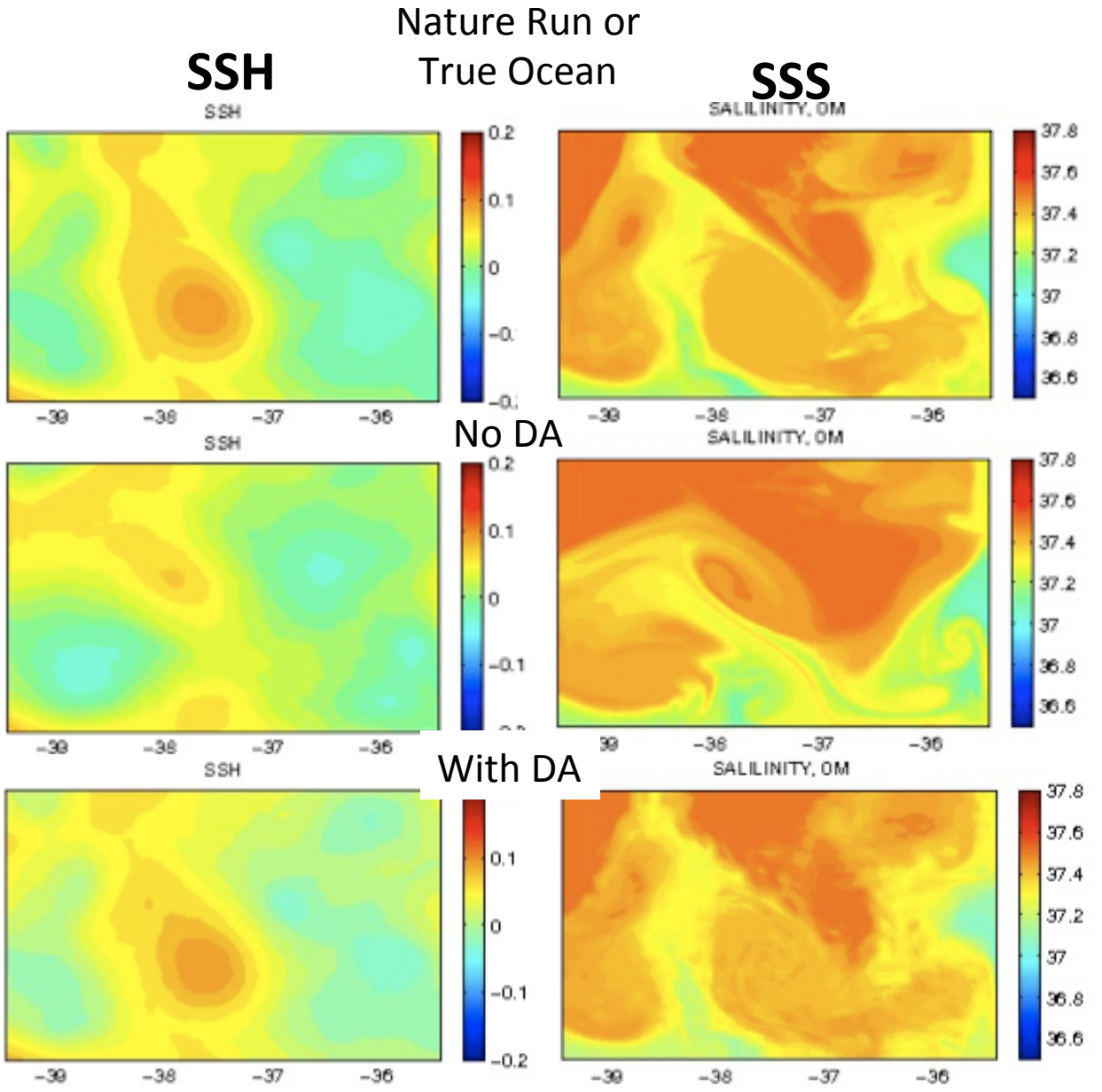


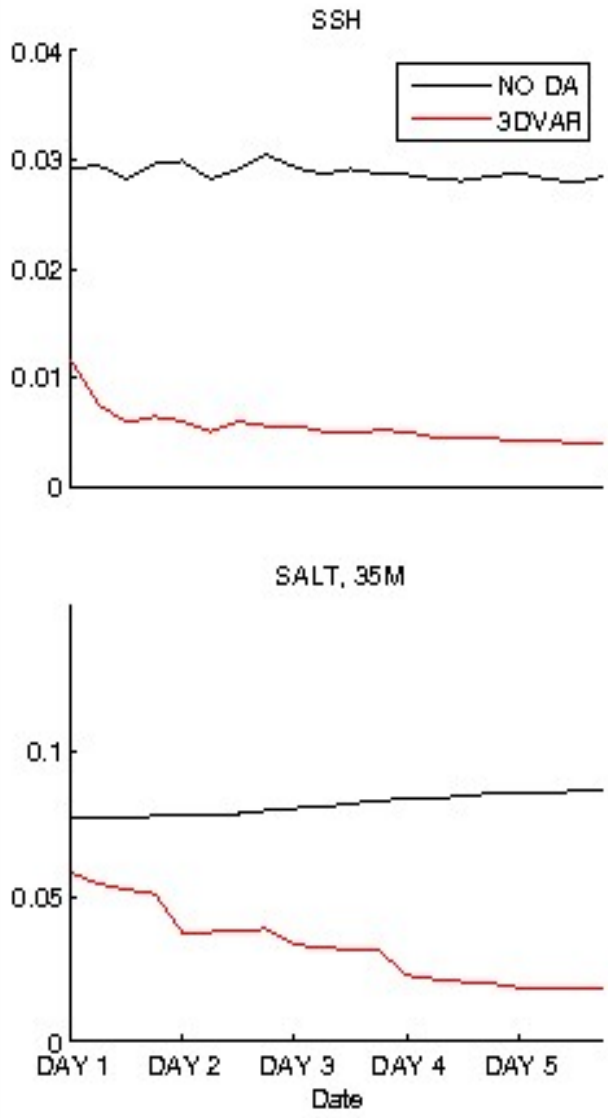
# OSSEs to Design Sampling Strategy




Glider  Ship CTDs  Drifters

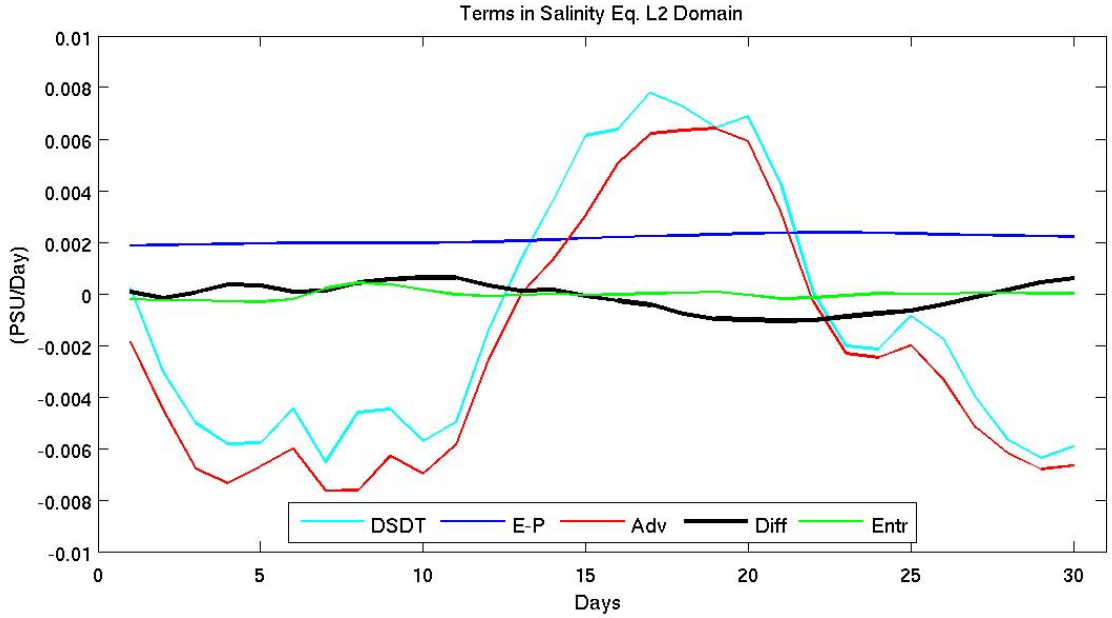
# OSSEs to Quantify the Data Impact

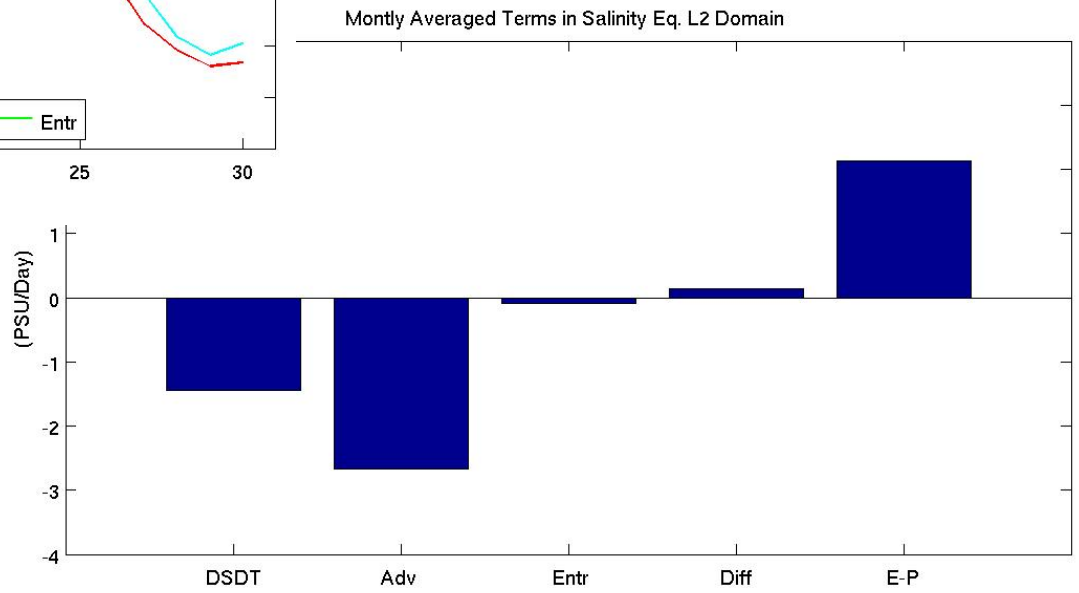


# Diagnostics of SSS Balance

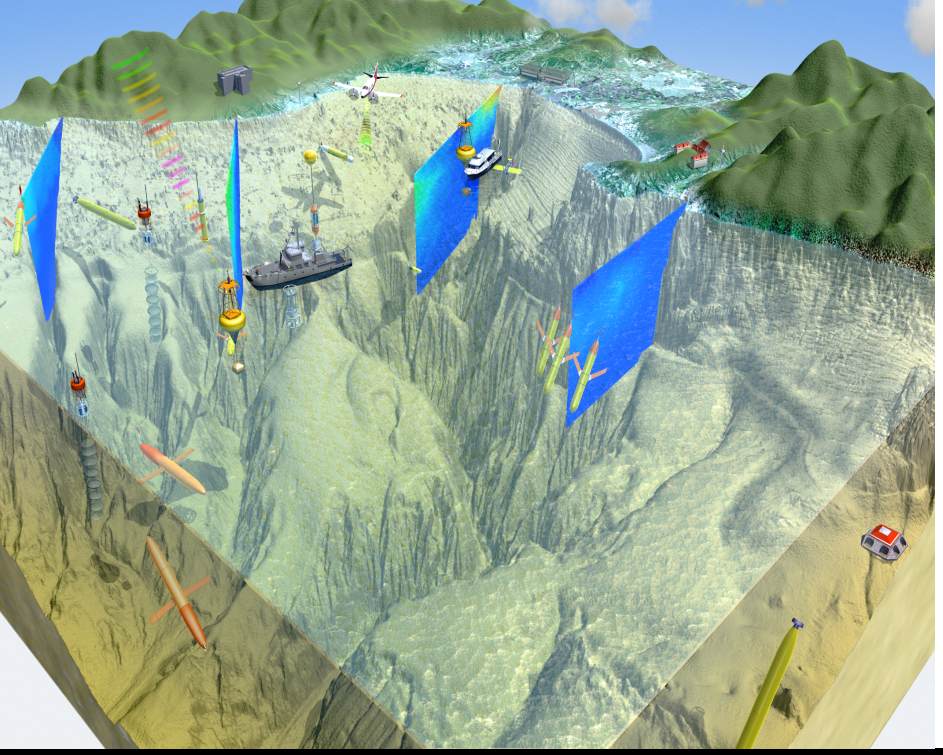
$$\underbrace{h\frac{\partial\langle S\rangle}{\partial t}}_{a}=\underbrace{-h\langle\vec{u}\rangle\bullet\nabla\langle S\rangle-\nabla\bullet\int_{-h}^{0}\hat{\vec{u}}\hat{S}dz}_{b,c}-\underbrace{\left(\langle S\rangle-S_{-h}\right)\left(\frac{\partial h}{\partial t}+\vec{u}_{-h}\bullet\nabla h+w_{-h}\right)}_{d}+\underbrace{\left(E-P\right)S_0}_{e}+\underbrace{SSM}_{f}$$

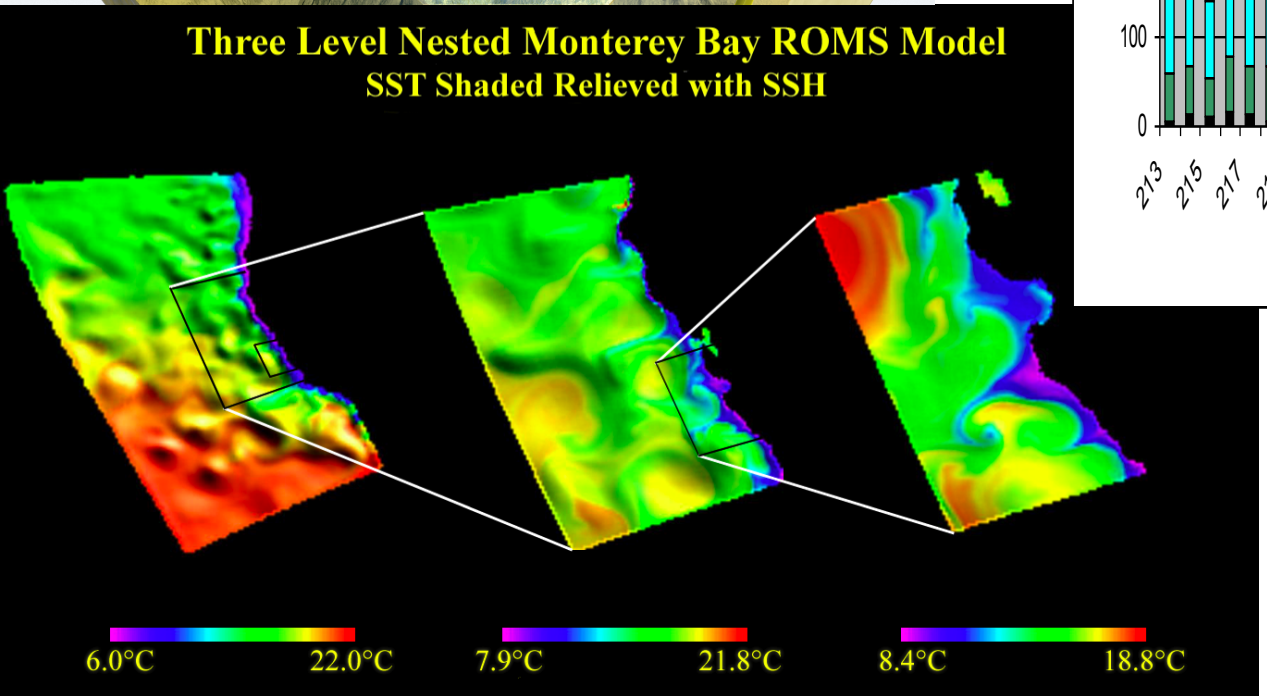


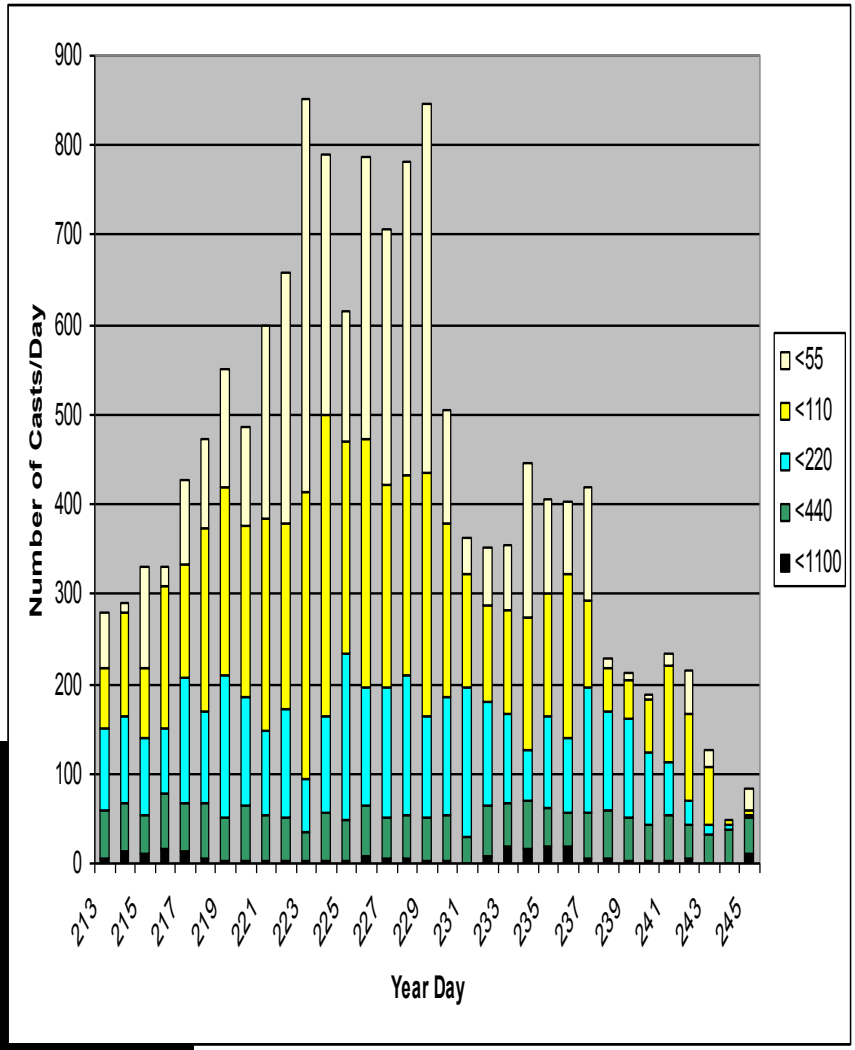



# Proposed Tasks

- **Year 1**
  - Implement the 3-domain nested ROMS & MS-3DVAR data assimilation system
  - Perform OSSE runs to support deployment design
  - Validate the atmospheric forcing against the flux mooring data to be deployed by SPURS with a particular focus on the air-sea heat flux and precipitation
- **Year 2:**
  - Start the daily ROMS analysis and forecasting cycle in the real-time 24/7 mode
- **Year 3:**
  - Perform reanalysis
  - Carry out diagnostic study of the dynamical processes influencing the upper ocean salinity using ROMS output at 9-km, 3-km, and 1-km, respectively






# Monterey Bay
# California
# 2003
# 2006

# Backup Slides

# Atmospheric Wind Forcing